

## Concrete Harvesting plans in Spain. Zorita NPP concrete Project.

---

Javier Sánchez, IETcc-CSIC. Spain.

[javier.sanchez@csic.es](mailto:javier.sanchez@csic.es)

# Outline

1. Introduction
  - › Plant Description
  - › Objectives
2. Concrete Damages due to Irradiation
  - › Reactor's Biological Shielding
  - › Spent Fuel's Pool
  - › Hot Leg
  - › Exterior of Containment Building
3. Test plan of non irradiated concrete

# 1. Introduction

## Plant Description

- Zorita NPP consists of a PWR reactor, 1 loop, W design. 160 Mwe output
- The plant is owned by Gas Natural Fenosa
- It was commissioned in 1968, and it operated until 2006
- On February 2010, ENRESA took the responsibility for decommissioning the station



José Cabrera NPP (Zorita)

# 1. Introduction

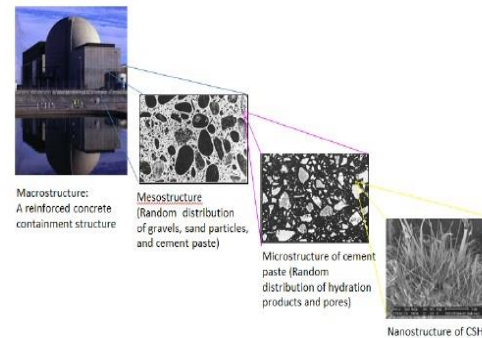
## Objectives

### Chance

- José Cabrera (Zorita) NPP under a Dismantling Process
- 29 complete cycles of operation
- 38 commercial operation years (26.36 Effective Full Power Years - EFPY)
- Concrete pieces available from different plant structures at the same time

### Effects to Study

- High Radiation → Reactor's Biological Shielding
- High Temperature → Hot Leg
- Aggressive Chemicals → Spent Fuel's Pool
- Outdoor Environment → Exterior of Containment Building



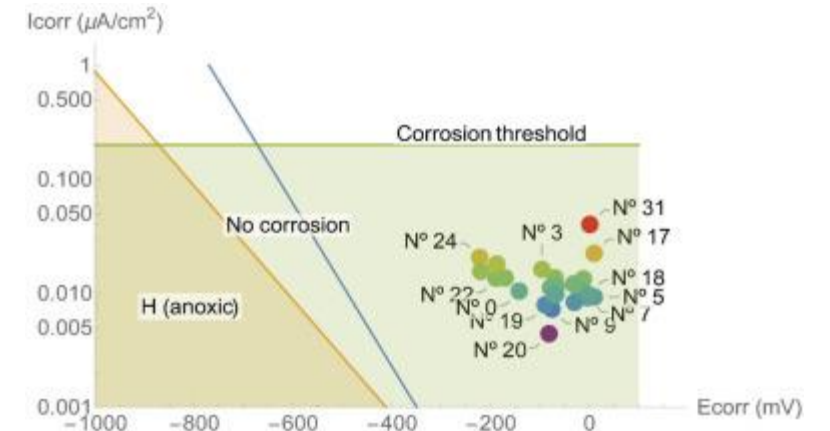
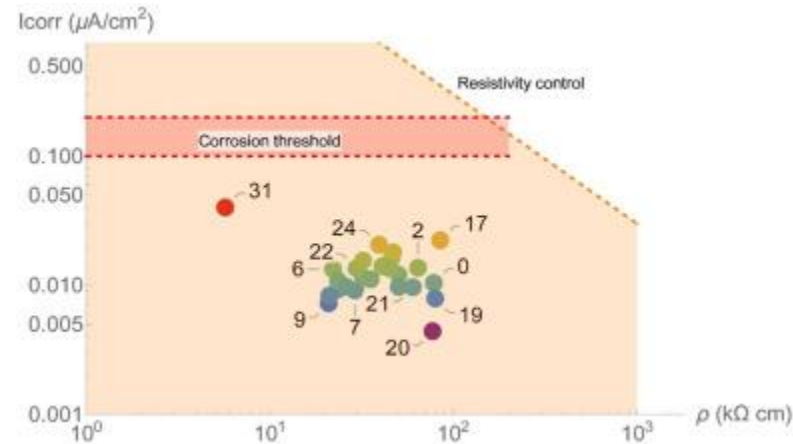
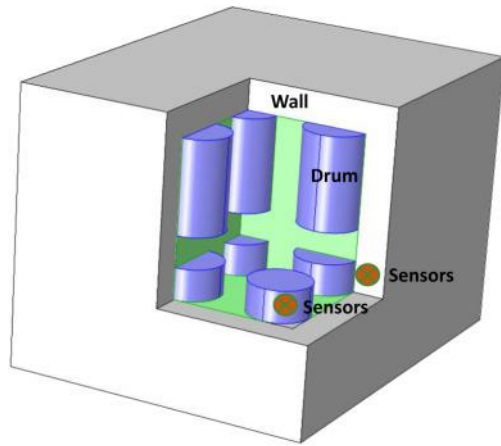
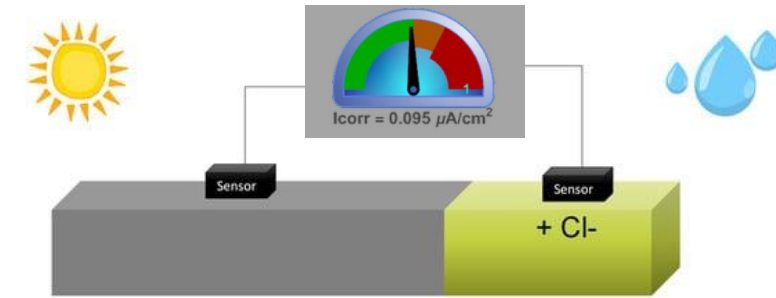
# 1. Introduction

## In-situ studies

Durability measurements of reinforced concrete structures & liner:

- Corrosión potential
- Resistivity
- Corrosion rate

Monitoring?



N Rebolledo, J Torres, S Chinchón-Payá, J Sánchez, S de Gregorio, M Ordóñez, I López. Monitoring in a reinforced concrete structure for storing low and intermediate level radioactive waste. Lessons learnt after 25 years, Nuclear Engineering and Technology, 55, 4, 2023. <https://doi.org/10.1016/j.net.2022.12.004>.

Rebolledo N, Torres JE, Silva A, Sánchez J. Monitoring of Reinforced Concrete Corrosion: Active and Passive Bars Exposed to Climate. *Applied Sciences*. 2024; 14(11):4665. <https://doi.org/10.3390/app14114665>

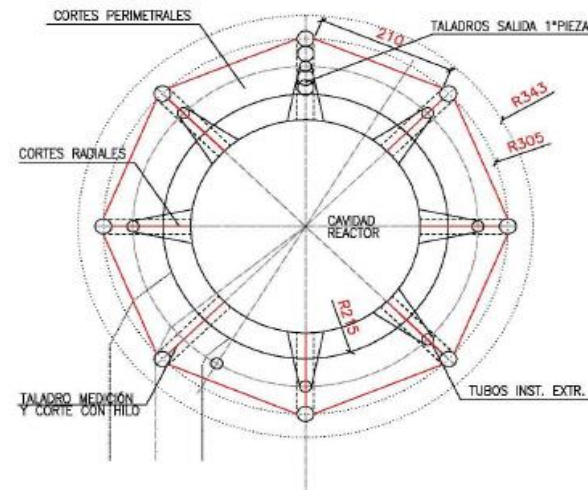
# Sample Extraction Plan

2

## 2. Sample Extraction Plan

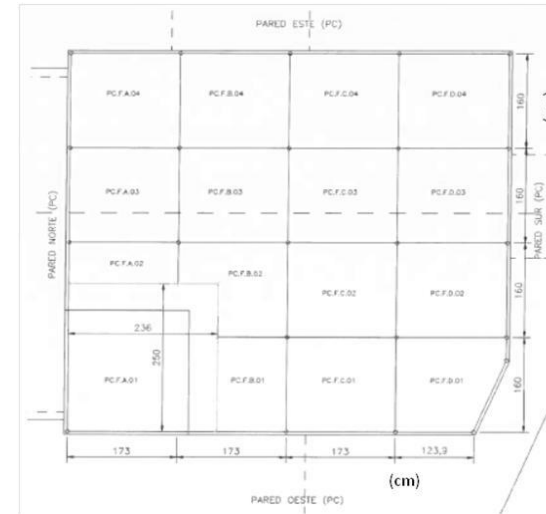
### Reactor's Biological Shielding

- Segmentation is concentric to the reactor cavity axis, whose radius is 175 cm
- Biological shielding is cut in 8 primary radial blocks
- From each primary block, 4 samples are extracted, except two, due to the internal instrumentation of the reactor
- Samples are extracted according the map of maximum neutron fluence
- 24 samples are to be extracted from biological shielding

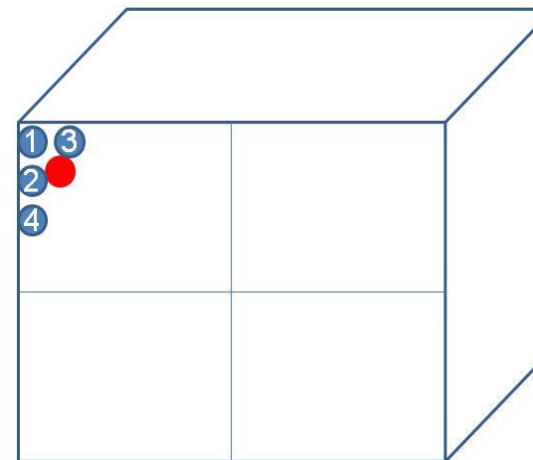


## 2. Sample Extraction Plan Spent Fuel's Pool

- Samples extracted from de PC.FA.04 block of the Spent Fuel's Pool
- Samples are nearest to the pool sump (red point), because it is the point with maximum contact with boric acid
- 4 samples are extracted from Spent Fuel's Pool



BLOQUE PC.FA.04



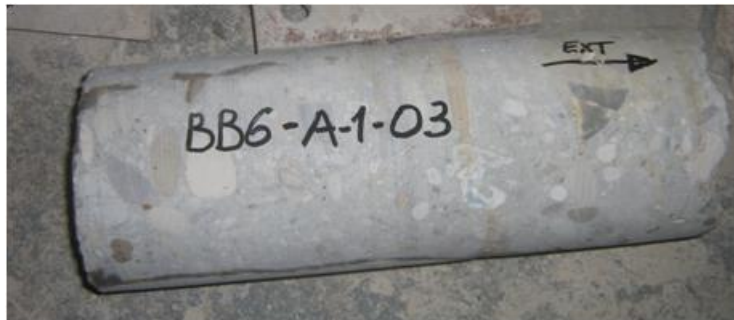
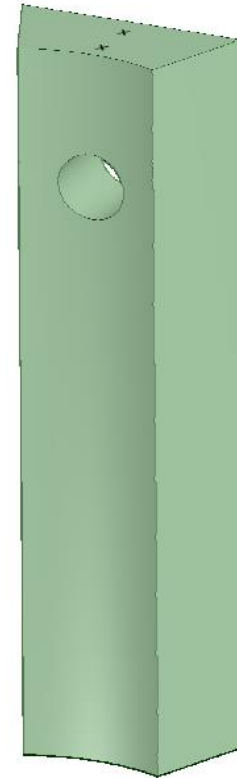
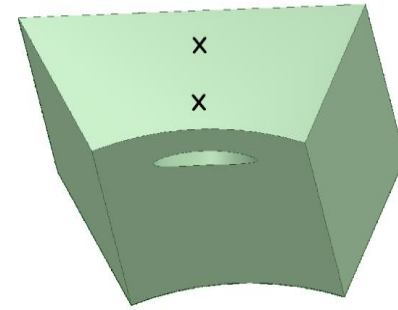
173 cm



## 2. Sample Extraction Plan

### Hot Leg

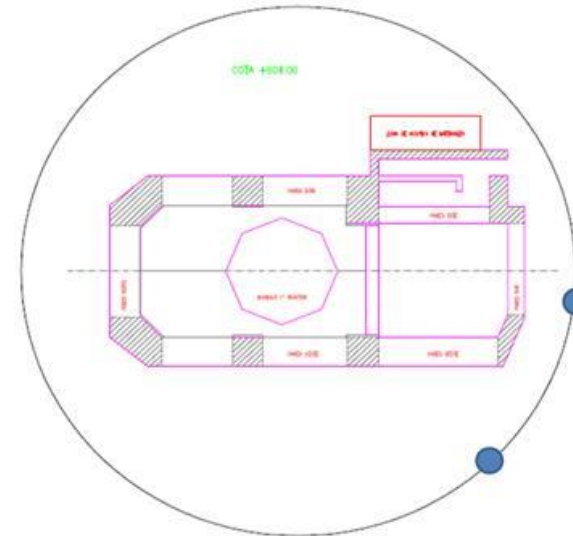
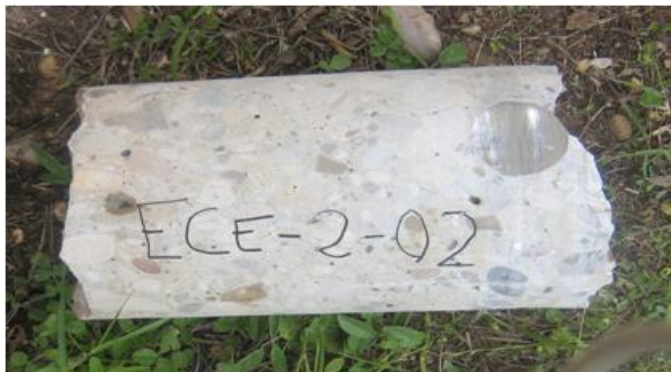
- > Hot Leg coincides with the top of 6<sup>th</sup> block of the Biological Shielding
- > Objective is to study the effects of high temperature on the concrete aging
- > 2 samples are extracted from Hot Leg



## 2. Sample Extraction Plan

### Exterior of Containment Building

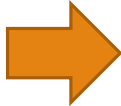
- Extraction zones are South and South-West of containment building
- 4 samples are extracted from the exterior of containment building
- 2 samples at 30 cm above ground level
- 2 samples at 15 cm below ground level



# Test plan of non irradiated concrete

3

# Samples

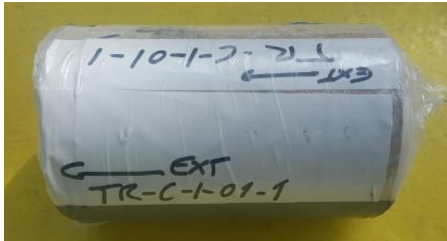


**59 SPECIMENS**

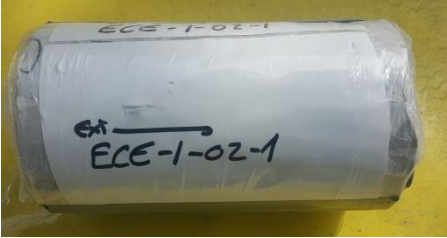


## EXTRACTION ZONE

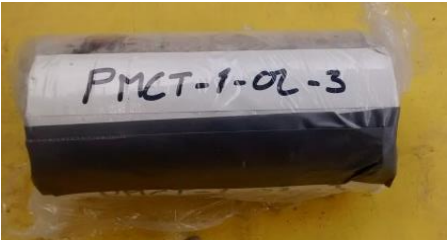
REFERENCE SPECIMENS  
**TRC**



SPECIMENS EXTERIOR  
CONTAINMENT BUILDING  
**ECE**



SPECIMENS MOBILE  
PARTS TRANSFER CHANNEL  
**PMCT**



BIOLOGICAL SHIELDING  
**BB**

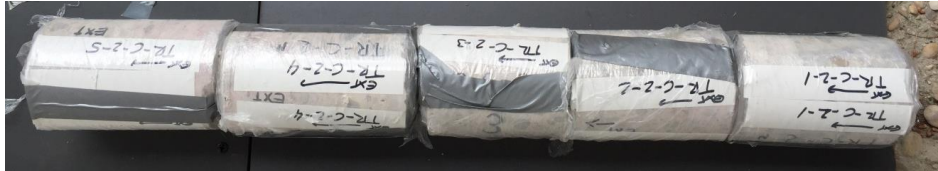


# Samples

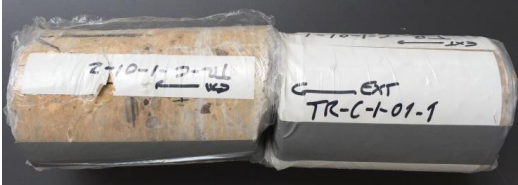
TYPE	SPECIMEN ID	PARTS	EXTRACTION ZONE	DATE	DIAMETER (mm)	PART LENGTH (mm)	TOTAL LENGTH (mm)	CONTAINER
REFERENCE SPECIMENS CUBICLE CH1- LEVEL 611 TRC	TR-C-1-01	TR-C-1-01-1	C-04-03-1- SOUTH WALL	11/23/16	152	210	440	CMB-DJ-07207
		TR-C-1-01-2	C-04-03-1- SOUTH WALL	11/23/16	152	240		CMB-DJ-07207
	TR-C-1-02	TR-C-1-02	C-04-03-1- SOUTH WALL	05/18/16	152	240	240	CMB-DJ-07207
	TR-C-1-03	TR-C-1-03-1	C-04-03-1- SOUTH WALL	11/23/16	152	200	390	CMB-DJ-07207
		TR-C-1-03-2	C-04-03-1- SOUTH WALL	11/23/16	152	190		CMB-DJ-07207
	TR-C-2	TR-C-2-1	C-04-03-1- SOUTH WALL	11/23/16	152	210	1050	CMB-DJ-07207
		TR-C-2-2	C-04-03-1- SOUTH WALL	11/23/16	152	200		CMB-DJ-07207
		TR-C-2-3	C-04-03-1- SOUTH WALL	11/23/16	152	200		CMB-DJ-07207
		TR-C-2-4	C-04-03-1- SOUTH WALL	11/23/16	152	220		CMB-DJ-07207
		TR-C-2-5	C-04-03-1- SOUTH WALL	11/23/16	152	220		CMB-DJ-07207
	TR-C-3-01	TR-C-3-01	C-04-03-1- SOUTH WALL	05/20/16	152	120	120	CMB-DJ-07207
	TR-C-3-02	TR-C-3-02-1	C-04-03-1- SOUTH WALL	11/23/16	152	230	500	CMB-DJ-07207
		TR-C-3-02-2	C-04-03-1- SOUTH WALL	11/23/16	152	270		CMB-DJ-07207
	TR-C-4-01	TR-C-4-01-1	C-04-03-1- SOUTH WALL	11/23/16	152	200	580	CMB-DJ-07207
		TR-C-4-01-2	C-04-03-1- SOUTH WALL	11/23/16	152	200		CMB-DJ-07207
		TR-C-4-01-3	C-04-03-1- SOUTH WALL	11/23/16	152	180		CMB-DJ-07207
	TR-C-4-02	TR-C-4-02-1	C-04-03-1- SOUTH WALL	11/23/16	152	200	400	CMB-DJ-07207
		TR-C-4-02-2	C-04-03-1- SOUTH WALL	11/23/16	152	200		CMB-DJ-07207
	TR-C-4-03	TR-C-4-03	C-04-03-1- SOUTH WALL	05/19/16	152	90	90	CMB-DJ-07207

# Samples

TR-C-2



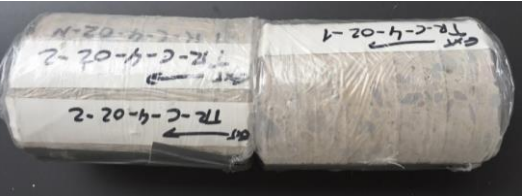
TR-C-1-01



TR-C-3-01



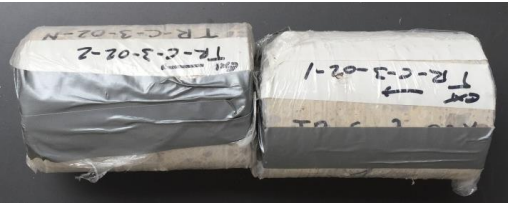
TR-C-4-02



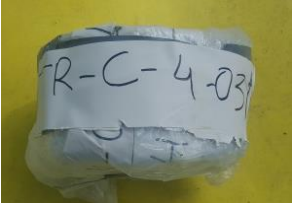
TR-C-1-02



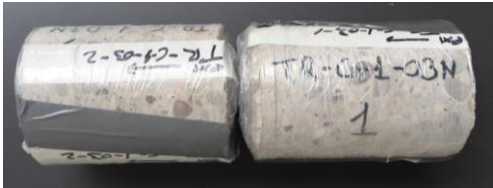
TR-C-3-02



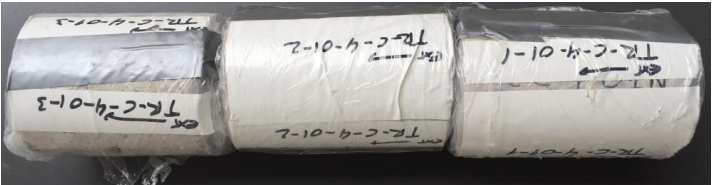
TR-C-4-03



TR-C-1-03



TR-C-4-01

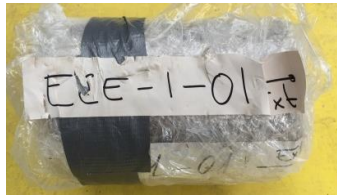


# Samples

TYPE	SPECIMEN ID	PARTS	EXTRACTION ZONE	DATE	DIAMETER (mm)	PART LENGTH (mm)	TOTAL LENGTH (mm)	CONTAINER
SPECIMENS EXTERIOR CONTAINMENT BUILDING ECE	ECE-1-01	ECE-1-01	SOUTH WALL	05/24/16	152	180	180	CMB-DJ-07207
	ECE-1-02	ECE-1-02-1	SOUTH WALL	11/23/16	152	240	470	CMB-DJ-07207
		ECE-1-02-2	SOUTH WALL	11/23/16	152	230		CMB-DJ-07207
	ECE-2-01	ECE-2-01	SOUTH WALL	05/23/16	152	170	170	CMB-DJ-07207
	ECE-2-02	ECE-2-02	SOUTH WALL	05/23/16	152	225	225	CMB-DJ-07207
	ECE-2-03	ECE-2-03	SOUTH WALL	05/23/16	152	260	260	CMB-DJ-07207
	ECE-3-01	ECE-3-01	SOUTHWEST WALL	05/23/16	152	140	140	CMB-DJ-07207
	ECE-3-02	ECE-3-02-1	SOUTHWEST WALL	11/23/16	152	210	480	CMB-DJ-07207
		ECE-3-02-2	SOUTHWEST WALL	11/23/16	152	270		CMB-DJ-07207
	ECE-4-01	ECE-4-01	SOUTHWEST WALL	12/13/16	152	110	110	CMB-DJ-07207
	ECE-4-02	ECE-4-02	SOUTHWEST WALL	12/13/16	152	410	410	CMB-DJ-07207
ECE-4-03	ECE-4-03	SOUTHWEST WALL	12/13/16	152	250	250	CMB-DJ-07207	

# Samples

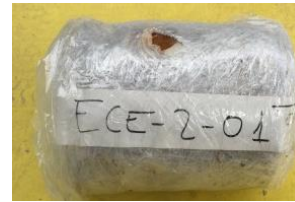
ECE-1-01



ECE-1-02



ECE-2-01



ECE-2-02



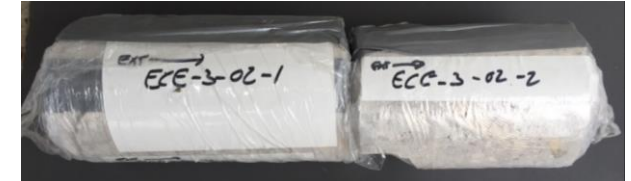
ECE-2-03



ECE-3-01



ECE-3-02



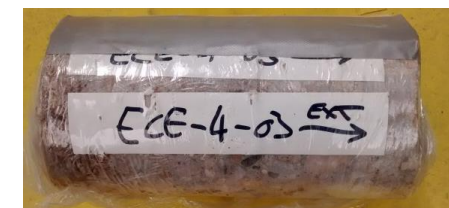
ECE-4-01



ECE-4-02



ECE-4-03





# Samples

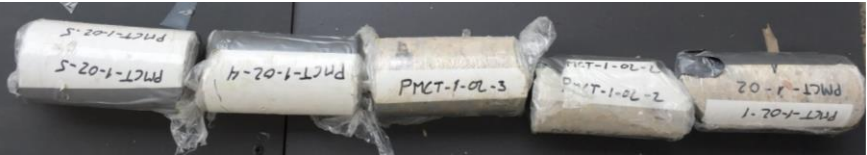
TYPE	SPECIMEN ID	PARTS	EXTRACTION ZONE	DATE	DIAMETER (mm)	PART LENGTH (mm)	TOTAL LENGTH (mm)	CONTAINER
SPECIMENS MOBILE PARTS TRANSFER CHANNEL PMCT	PMCT-1-01	PMCT-1-01-1	Mobile Parts Transfer Channel	11/25/16	100	160	300	CMB-DJ-07207
		PMCT-1-01-2	Mobile Parts Transfer Channel	11/25/16	100	140		CMB-DJ-07207
	PMCT-1-02	PMCT-1-02-1	Mobile Parts Transfer Channel	11/25/16	100	210	1030	CMB-DJ-07207
		PMCT-1-02-2	Mobile Parts Transfer Channel	11/25/16	100	220		CMB-DJ-07207
		PMCT-1-02-3	Mobile Parts Transfer Channel	11/25/16	100	200		CMB-DJ-07207
		PMCT-1-02-4	Mobile Parts Transfer Channel	11/25/16	100	200		CMB-DJ-07207
		PMCT-1-02-5	Mobile Parts Transfer Channel	11/25/16	100	200		CMB-DJ-07207
	PMCT-2-01	PMCT-2-01-1	Mobile Parts Transfer Channel	11/25/16	100	170	340	CMB-DJ-07207
		PMCT-2-01-2	Mobile Parts Transfer Channel	11/25/16	100	170		CMB-DJ-07207
	PMCT-2-02	PMCT-2-02-1	Mobile Parts Transfer Channel	11/25/16	100	150	280	CMB-DJ-07207
		PMCT-2-02-2	Mobile Parts Transfer Channel	11/25/16	100	130		CMB-DJ-07207
	PMCT-2-03	PMCT-2-03-1	Mobile Parts Transfer Channel	11/25/16	100	200	800	CMB-DJ-07207
		PMCT-2-03-2	Mobile Parts Transfer Channel	11/25/16	100	200		CMB-DJ-07207
		PMCT-2-03-3	Mobile Parts Transfer Channel	11/25/16	100	190		CMB-DJ-07207
		PMCT-2-03-4	Mobile Parts Transfer Channel	11/25/16	100	210		CMB-DJ-07207
	PMCT-6-01	PMCT-6-01-1	Mobile Parts Transfer Channel	11/25/16	100	200	500	CMB-DJ-07207
		PMCT-6-01-2	Mobile Parts Transfer Channel	11/25/16	100	130		CMB-DJ-07207
		PMCT-6-01-3	Mobile Parts Transfer Channel	11/25/16	100	170		CMB-DJ-07207
	PMCT-6-02	PMCT-6-02-1	Mobile Parts Transfer Channel	11/25/16	100	200	630	CMB-DJ-07207
		PMCT-6-02-2	Mobile Parts Transfer Channel	11/25/16	100	170		CMB-DJ-07207
PMCT-6-02-3		Mobile Parts Transfer Channel	11/25/16	100	260	CMB-DJ-07207		
PMCT-8-01	PMCT-8-01	Mobile Parts Transfer Channel	11/25/16	100	230	230	CMB-DJ-07207	
PMCT-8-02	PMCT-8-02	Mobile Parts Transfer Channel	11/25/16	100	145	145	CMB-DJ-07207	
PMCT-8-03	PMCT-8-03	Mobile Parts Transfer Channel	11/25/16	100	260	260	CMB-DJ-07207	
PMCT-8-04	PMCT-8-04	Mobile Parts Transfer Channel	11/25/16	100	150	150	CMB-DJ-07207	

# Samples

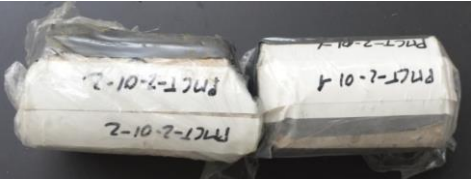
PMCT-1-01



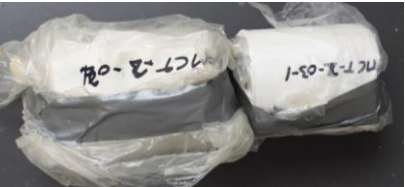
PMCT-1-02



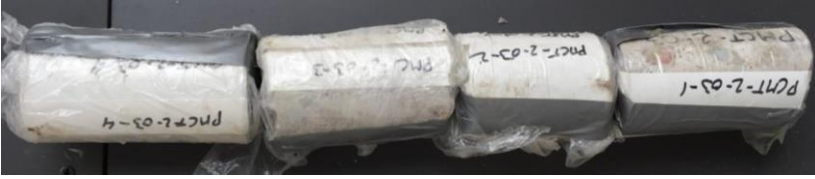
PMCT-2-01



PMCT-2-02



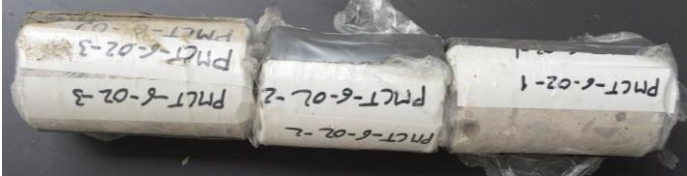
PMCT-2-03



PMCT-6-01



PMCT-6-02



PMCT-8-01



PMCT-8-02



PMCT-8-03



PMCT-8-04



# Samples

TYPE	SPECIMEN ID	PARTS	EXTRACTION ZONE	DATE	DIMENSIONS (mm)
BIOLOGICAL SHIELDING BB	BB-P-4-2	BB-P-4-2	BIOLOGICAL PROTECTION/MIDDLE	17/11/2016	130X130X200
	BB-P-7-4	BB-P-7-4	BIOLOGICAL PROTECTION/EXTERIOR	15/11/2016	130X130X200
	BB-P-8-1	BB-P-8-1	BIOLOGICAL PROTECTION/INTERIOR	15/11/2016	130X130X200

BB-P-4-2



BB-P-7-4



BB-P-8-1



# PICK OUT SPECIMENS FOR TESTING

EXTRACTION ZONE	SPECIMEN ID	PARTS	OBSERVATIONS
REFERENCE SPECIMENS CUBICLE CH1- LEVEL 611 <b>TRC</b>	TR-C-1-01	TR-C-1-01-1	CUBICLE CH1- LEVEL 611
	TR-C-2	TR-C-2-1	CUBICLE CH1- LEVEL 611
	TR-C-2	TR-C-2-3	CUBICLE CH1- LEVEL 611
	TR-C-2	TR-C-2-4	CUBICLE CH1- LEVEL 611
	TR-C-2	TR-C-2-5	CUBICLE CH1- LEVEL 611
SPECIMENS EXTERIOR CONTAINMENT BUILDING <b>ECE</b>	ECE-1-02	ECE-1-02-1	SOUTH WALL / 30 cm aboveground
	ECE-1-02	ECE-1-02-2	SOUTH WALL / 30 cm cm aboveground
	ECE-2-01	ECE-2-01	SOUTH WALL / 15 cm underground
	ECE-2-02	ECE-2-02	SOUTH WALL / 15 cm underground
	ECE-3-01	ECE-3-01	SOUTHWEST WALL / 30 cm aboveground
	ECE-3-02	ECE-3-02-1	SOUTHWEST WALL / 30 cm aboveground
	ECE-3-02	ECE-3-02-2	SOUTHWEST WALL / 30 cm aboveground
	ECE-4-01	ECE-4-01	SOUTHWEST WALL / 15 cm underground
	ECE-4-02	ECE-4-02	SOUTHWEST WALL / 15 cm underground
SPECIMENS MOBILE PARTS TRANSFER CHANNEL <b>PMCT</b>	PMCT-1-02	PMCT-1-02-1	MOBILE PARTS TRANSFER CHANNEL
	PMCT-1-02	PMCT-1-02-2	MOBILE PARTS TRANSFER CHANNEL
	PMCT-1-02	PMCT-1-02-3	MOBILE PARTS TRANSFER CHANNEL
	PMCT-2-01	PMCT-2-01-1	MOBILE PARTS TRANSFER CHANNEL
BIOLOGICAL SHIELDING <b>BB</b>	BB-P-7-4	BB-P-7-4	BIOLOGICAL PROTECTION/EXTERIOR
	BB-P-8-1	BB-P-8-1	BIOLOGICAL PROTECTION/INTERIOR

# SPECIMENS

## REFERENCE SPECIMENS TRC

TR-C-1-01-1



TR-C-2-1



TR-C-2-3



TR-C-2-4



TR-C-2-5



## SPECIMENS EXTERIOR CONTAINMENT BUILDING ECE

ECE-1-02-1



ECE-1-02-2



ECE-2-01



ECE-4-01



ECE-4-02



ECE-2-02



ECE-3-01



ECE-3-02-1



ECE-3-02-2



## SPECIMENS MOBILE PARTS TRANSFER CHANNEL PMCT

PMCT-1-02-1



PMCT-1-02-2



PMCT-1-02-3



PMCT-2-01-1



## BIOLOGICAL PROTECTION BB

BB-P-74



BB-P-81



# TESTS

EXTRACTION ZONE	DT	NDT
REFERENCE SPECIMENS CUBICLE CH1- LEVEL 611 <b>TRC</b>	Porosity Microscopy Carbonation depth ATD DRX Tomography Petrography Water Porosity ** Mechanical strength ***	Resistivity * Ultrasonic velocity * Schmidt hammer
SPECIMENS EXTERIOR CONTAINMENT BUILDING <b>ECE</b>		
SPECIMENS MOBILE PARTS TRANSFER CHANNEL <b>PMCT</b>		
BIOLOGICAL SHIELDING <b>BB</b>		

\* Dry and wet

\*\* the water porosity on saturated specimens

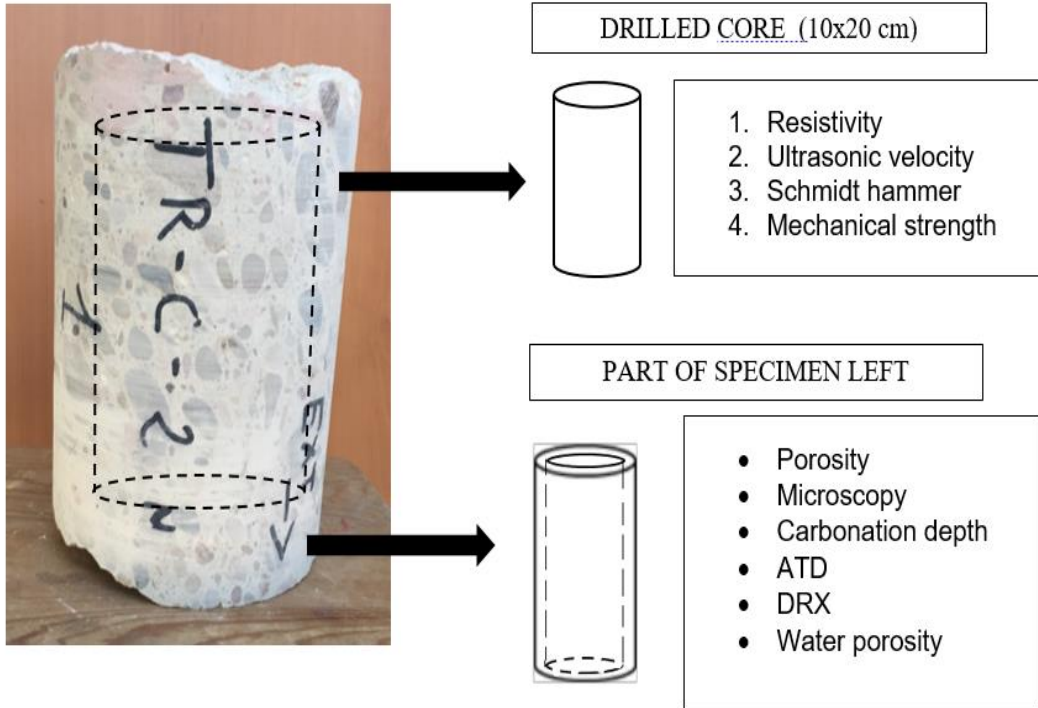
\*\*\* The mechanical strength on cylindrical specimens without Steel of 15x30, 10x20 y 6x12 cm

# Specimen-test

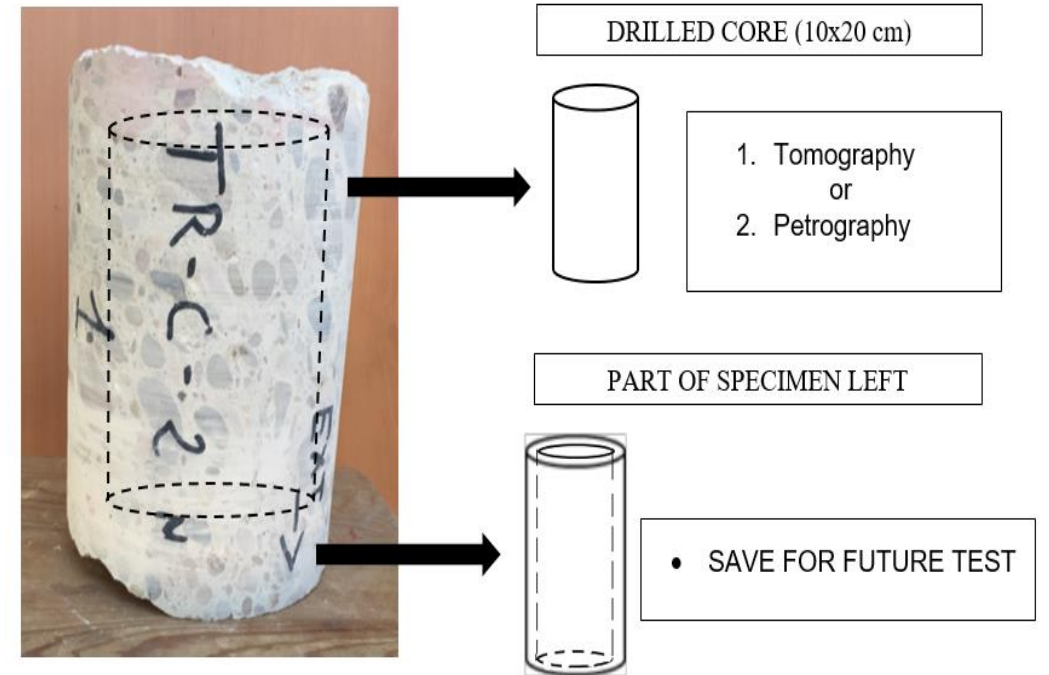
EXTRACTION ZONE	SPECIMEN ID	PARTS	TEST
REFERENCE SPECIMENS CUBICLE CH1- LEVEL 611 <b>TRC</b>	TR-C-1-01	TR-C-1-01-1	PETROGRAPHY
	TR-C-2	TR-C-2-1	DT AND NDT
	TR-C-2	TR-C-2-3	DT AND NDT
	TR-C-2	TR-C-2-4	TOMOGRAPHY
	TR-C-2	TR-C-2-5	PETROGRAPHY
SPECIMENS EXTERIOR CONTAINMENT BUILDING <b>ECE</b>	ECE-1-02	ECE-1-02-1	DT AND NDT
	ECE-1-02	ECE-1-02-2	PETROGRAPHY
	ECE-2-01	ECE-2-01	TOMOGRAPHY
	ECE-2-02	ECE-2-02	DT AND NDT
	ECE-3-01	ECE-3-01	TOMOGRAPHY
	ECE-3-02	ECE-3-02-1	DT AND NDT
	ECE-3-02	ECE-3-02-2	PETROGRAPHY
	ECE-4-01	ECE-4-01	TOMOGRAPHY
	ECE-4-02	ECE-4-02	DT AND NDT
SPECIMENS MOBILE PARTS TRANSFER CHANNEL <b>PMCT</b>	PMCT-1-02	PMCT-1-02-1	TOMOGRAPHY
	PMCT-1-02	PMCT-1-02-2	DT AND NDT
	PMCT-1-02	PMCT-1-02-3	PETROGRAPHY
	PMCT-2-01	PMCT-2-01-1	DT AND NDT
BIOLOGICAL SHIELDING <b>BB</b>	BB-P-7-4	BB-P-7-4	TOMOGRAPHY
	BB-P-8-1	BB-P-8-1	TOMOGRAPHY

# EXAMPLE

## DT AND NDT



## PETROGRAPHY OR TOMOGRAPHY





# Concrete Harvesting plans in Spain. Zorita NPP concrete Project.

Thanks!!!

---

Javier Sánchez, IETcc-CSIC. Spain.

[javier.sanchez@csic.es](mailto:javier.sanchez@csic.es)